

# MONITORING PLAN

# 11

**T**he NHEP Management Plan presents a series of goals, objectives, and specific actions designed to improve, protect, and enhance the environmental quality of the state's estuaries, and outlines a process for implementing the Plan's most critical actions. Measuring the effectiveness of these actions in achieving NHEP goals is an essential part of implementation. Understanding the status and trends in environmental quality will help the NHEP evaluate the success of the Management Plan, and provide information that can be used to redirect or refocus implementation efforts as needed. The NHEP staff will continually track and evaluate information from NHEP programs. The NHEP Monitoring Program will generate information needed to answer the following questions.

- Are the goals and objectives of the Management Plan being met?
- Are the actions in the Management Plan having the desired effect?

Although many agencies and organizations monitor various aspects of New Hampshire's estuaries, there is not a coordinated, integrated, comprehensive monitoring plan in place. The purpose of the NHEP Monitoring Program is to provide scientifically credible information which increases understanding of New Hampshire's estuaries, its resources, and the effects of human activities over time. The monitoring program has been designed to ensure that high quality data are collected and analyzed and that results are made available to many audiences.

The overall goal of the NHEP Monitoring Program is to develop a better understanding of the status and trends of environmental quality in coastal New Hampshire. Therefore, the Monitoring Plan's central focus asks:

- Is the environmental condition of the estuaries and their resources improving over time?

## SCOPE

The NHEP Monitoring Plan focuses on the New Hampshire Estuary Project study area, which includes the 43-municipality watershed that drains to the tidal rivers and Great Bay and Hampton Harbor estuaries. Although most of the actual data collection will occur in the tidal portions of the watershed, upper watershed influences will be considered. For example, the NH Department of Environmental Services will restructure aspects of its ambient sampling regime for freshwater tributaries to be consistent with the monitoring goals of the NHEP Monitoring Plan.

Although the Monitoring Plan is intended to be comprehensive and all inclusive, the resources needed to enact a comprehensive program cannot be met in the short term. The Monitoring Plan has identified gaps in data and information from all existing monitoring efforts, and selected additional monitoring activities to be initiated in 2001. As resources become available and our knowledge base increases, the scope and coverage of the NHEP monitoring program will likely expand or change. The NHEP intends to periodically update the Monitoring Plan to reflect new knowledge, changing priorities, and emerging issues.

## RELATIONSHIP TO THE MANAGEMENT PLAN

The NHEP Management Plan sets management goals for a series of major environmental management issues: water quality, shellfish, land use and habitat protection, habitat restoration, and outreach and education. The goals of the Monitoring Plan are derived from the goals of the Management Plan. Table 1 shows the monitoring goals and the related management goals.

To develop a Monitoring Plan that is tied to the NHEP Management Plan, the objectives of the Monitoring Plan were derived from the objectives of the Management Plan. Management Plan objectives were converted into monitoring questions. For example, the Management Plan objective, "Achieve water quality in Great Bay and Hampton Harbor that meets shellfish harvest standards," became the monitoring question, "Do NH tidal waters meet fecal coliform standards of the National Shellfish Sanitation Program for approved shellfish areas?" The complete list of monitoring questions, found on pages 11-46 to 11-48, defines the information that a comprehensive monitoring plan could gather.

The monitoring questions were prioritized by project participants based on the importance and relevance as indicators of environmental quality and change. The monitoring questions that were voted highest priority were developed into the objectives of the Monitoring Plan. The monitoring objectives, their related management objectives, and the relevant management Action Plans are included in Table 2.

**Table 1: Program Goals**

MONITORING GOALS	MANAGEMENT GOALS
<p><b>Water Quality</b></p> <ul style="list-style-type: none"> <li>■ Determine the status and trends of the sanitary quality (bacteria and other disease-causing organisms) of shellfish-growing and recreational waters.</li> <li>■ Determine the status and trends of eutrophic conditions in New Hampshire's coastal and estuarine waters.</li> <li>■ Determine the status and trends of toxic contaminants in water, sediment, and biota of coastal New Hampshire.</li> </ul>	<p><b>Water Quality</b></p> <ul style="list-style-type: none"> <li>■ Ensure NH's estuarine waters will meet standards for pathogenic bacteria.</li> <li>■ Ensure NH's estuarine waters will meet standards for organic and inorganic nutrients</li> <li>■ Ensure NH's estuarine waters, sediments and biota meet standards for toxic contaminants.</li> </ul>
<p><b>Shellfish</b></p> <ul style="list-style-type: none"> <li>■ Determine the status and trends of shellfish populations in New Hampshire's coastal and estuarine waters.</li> </ul>	<p><b>Shellfish</b></p> <ul style="list-style-type: none"> <li>■ Achieve sustainable shellfish resources by tripling the area of shellfish beds that are classified open for harvesting to 75% of all beds, and tripling the quantity of harvestable clams and oysters.</li> <li>■ Assure shellfish are fit for human consumption and are support a healthy marine ecosystem</li> <li>■ Provide opportunities and strategies for restoration of shellfish communities and habitat.</li> <li>■ Support coordination to achieve environmentally sound shellfish aquaculture activities.</li> </ul>
<p><b>Land Use/Habitat Protection &amp; Restoration</b></p> <ul style="list-style-type: none"> <li>■ Determine the status and trends of land use, development, and habitat protection in the Seacoast region of New Hampshire.</li> <li>■ Determine the status and trends of critical species and habitats in New Hampshire's coastal and estuarine watersheds.</li> </ul>	<p><b>Land Use/Habitat Protection &amp; Restoration</b></p> <ul style="list-style-type: none"> <li>■ NH coastal watershed has development patterns that ensure the protection of estuarine water quality and preserve the rural quality of Great Bay.</li> <li>■ Maximize the acreage and health of tidal wetlands.</li> <li>■ Protect freshwater and tidal shorelands to ensure estuarine water quality.</li> <li>■ Protect estuarine water quality by ensuring that groundwater impacts are minimized.</li> <li>■ Allow no net loss of freshwater wetland functions.</li> <li>■ Maintain habitats of sufficient size and quality to support populations of naturally occurring plants, animals, and communities.</li> </ul>

**Table 2: Program Objectives**

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**WATER QUALITY - Bacteria**

Monitoring Objective	Management Objective	Action Plans
Objective A: To determine if concentrations of fecal borne microbial contaminants are increasing with time.	Minimize beach closures due to failure to meet water quality standards for tidal waters (Enterococci levels not exceeding 104 counts/100 ml. in any one sample)	WQ-3, 4A, 4B, 4C, 5, 6, 7, 8, 13, 14 SHL-2, 5
Objective B: To determine the effects of human-borne fecal microbial contaminants on surface water quality in coastal NH.	Increase water bodies in the NH coastal watershed designated 'swimmable' by achieving state water quality standards (E. coli levels not exceeding 406 counts/100 ml in any one sample. For designated beaches, E. coli should not exceed 88 counts/100 ml.)	
Objective C: To determine if the incidence and concentrations of microbial pathogens are changing with time.	Reduce the number of known illicit connections in the NH coastal watershed by 50% by 2010.	
Achieve water quality in Great Bay and Hampton Harbor that meets shellfish harvest standards (14 counts of fecal coliform/100 ml) by 2010.	Achieve 50% reduction of known illegal discharges into Great Bay, Hampton Harbor and the tributaries by 2010.	

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**WATER QUALITY - Toxic Contaminants**

Monitoring Objective	Management Objective	Action Plans
Objective A: To determine if toxic contaminant concentrations in seafood species from NH coastal waters are increasing with time.	Develop baseline of toxic impacts on ecological and human health by tracking toxic contaminants in water, sediment, and indicator species: blue mussels (Gulfwatch); tomcod, lobsters and winter flounder (Coastal 2000).	WQ- 2, 4B, 6, 7, 11, 12A, 12B, 15
Objective B: To determine if concentrations of toxic contaminants in sediments, water, and biota are increasing with time.	Long-term: Reduce toxic contaminants levels in water, sediment and indicator species so that no levels persist or accumulate according to:	
Objective C: To determine if toxic contaminants are causing increasingly prevalent toxic effects in marine and estuarine biota.	<ul style="list-style-type: none"><li>■ FDA guideline levels</li><li>■ State water standards in Ws 1700</li><li>■ Sediment levels below ER-M levels</li></ul>	

## WATER QUALITY - Nutrients and Eutrophication

Monitoring Objective	Management Objective	Action Plans
Objective A: To determine whether concentrations of dissolved and particulate nutrients are increasing as seacoast region development and population increases.	Maintain organic nutrients in Great Bay, Hampton Harbor and their tributaries at 1994-1996 NERR baseline levels.	WQ-1, 5, 6, 7, 8, 9, 10, 11, 15
Objective B: To determine whether concentrations of phytoplankton, measured by chlorophyll a, in NH tidal waters change over time.	Maintain dissolved oxygen levels at: <ul style="list-style-type: none"> <li>&gt; 4 mg/L for tidal rivers</li> <li>&gt; 6 mg/L for embayments (Great Bay and Little Bay)</li> <li>&gt; 7 mg/L for oceanic areas (Hampton Harbor and Atlantic Coast)</li> </ul>	
Objective C: To determine whether concentrations of suspended particulates, measured by TSS and particulate organic matter, turbidity, and secchi depth, in NH tidal waters change over time.	Maintain NPDES permit levels for BOD at wastewater facilities in the NH coastal watershed.	
Objective D: To determine whether the concentration of dissolved oxygen and percent oxygen saturation in NH tidal waters change over time.		
Objective E: To determine whether nuisance macroalgae increase in abundance and area in intertidal and shallow subtidal areas of the NH estuaries.		
Objective F: To determine whether eelgrass decreases in abundance, density and biomass, and area in intertidal and shallow subtidal areas of NH estuaries.		
Maintain inorganic nutrients, nitrogen, phosphorous and chlorophyll a in Great Bay, Hampton Harbor and their tributaries at 1998-2000 NERR baseline levels.		

## SHELLFISH

Monitoring Objective	Management Objective	Action Plans
Objective A: To determine whether the abundance and population structure of molluscan shellfish in NH estuaries change over time.	Maintain an approved National Shellfish Sanitation Program supported by the State.	SHL- 1, 2, 3, 4, 5, 6, 7, 8, 9A, 9B, 9C, 9D, 15
Objective B: To determine the status and trends of shellfish diseases.	Increase soft shell clam beds in Great Bay, Little Bay, and Hampton Harbor that are open for harvest to 2500 acres by 2010.	
Objective C: To determine how much of each species of molluscan shellfish is harvested from NH waters.	Survey each major oyster and soft-shell clam bed at a minimum of every 3 years for dimensions, density and population structure.	
Objective D: To determine the effects of predation on shellfish populations in NH tidal waters.	Achieve water quality in Great Bay and Hampton Harbor that will meet shellfish harvest standards by 2010.	
Objective E: To determine the effect of restoration on shellfish populations in NH tidal waters.	<p>Shellfish Acreage: No net decrease in acreage of oyster beds from 1997 amounts for Nannie Island, Woodman Point, Piscataqua River, Adams Point, Oyster Squamscott and Bellamy Rivers.</p> <p>Shellfish density:</p> <p>A) Oysters: No net decrease in oysters (&gt;80 mm) / square meter from 1997 amounts at Nannie Island, Woodman Point, Piscataqua River, Adams Point, and Oyster River.</p> <p>B) Clams: No net decrease in adult clams (&gt;50 mm) / square meter from the 1989-1999 10-year average at Common Island, Hampton River, and Middle Ground.</p> <p>Restore 20 acres of oyster habitat in Great Bay and its tidal tributaries.</p> <p>Ensure that aquaculture practices do not adversely impact water quality or ecological health of NH's estuaries.</p>	

## LAND USE AND HABITAT PROTECTION

Monitoring Objective	Management Objective	Action Plans
Objective A: To determine if the rate of land use change increases as human population and development increase in coastal NH.	Minimize the amount of impervious surfaces and assess the impacts to water quality by:  1) Keeping the total impervious surface in each sub-watershed below 10% of the total land area,  2) Reducing stormwater runoff from future development in all sub-watersheds, especially where impervious surfaces already exceed 10%.	LND-1, 2, 3, 4, 5, 6, 6A, 6B, 6C, 6D, 6E, 6F, 13, 14, 15, 16, 17, 26, 27, 28, 29, 32, 33, 34, 35, 36
Objective B: To determine if acreage of permanently protected important habitats increases as human population and development increase in coastal NH.	Determine existing acres of permanently protected land in the NH coastal watershed in the following categories: tidal shoreland, large contiguous forest blocks, wetlands with high habitat values, freshwater shorelands, rare and exemplary natural communities, by 2005.	
Objective C: To determine if the rate of sprawl increases as human population and development increase in coastal NH.	Increase acreage of protected land containing significant habitats in the NH coastal watershed, through fee acquisition or conservation easements by 2010.	
	Allow no new impervious surfaces or major disturbances of existing vegetation (except for water-dependent uses) in NH coastal watershed. In addition to state Shoreland Protection Act regulations, encourage additional reductions of shoreland impacts by 2010.	
	Allow no new establishment or expansion of existing contamination sources (such as salt storage, junk yards, solid waste, hazardous waste, etc.) within the shoreland protection area as tracked by the Department of Environmental Services.	
	Increase use of buffers around wildlife areas and maintaining contiguous habitat blocks in the NH coastal watershed by 2010.	
	Minimize the total rate of land consumption in the NH coastal watershed (as measured by acres of developed land per capita).	
	Encourage 43 coastal watershed municipalities to actively participate in addressing sprawl.	

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## CRITICAL SPECIES, HABITAT AND RESTORATION

Monitoring Objective	Management Objective	Action Plans
Objective A: To determine trends in wetland degradation and restoration.	Allow no loss or degradation of 6200 acres of tidal wetlands in the NH coastal watershed and restore 300 acres of tidal wetlands degraded by tidal restrictions by 2010.	LND-4, 7, 8A, 8B, 9A, 9B, 10, 11, 12, 18, 19, 20, 21, 22, 23, 24, 25, 25A, 25B, 25C, 25D, 30, 31
Objective B: To determine whether populations of resident and migratory finfish species change over time.	Determine indicators for freshwater wetland functions.	
Objective C: To determine the quantity and quality of groundwater entering estuarine and coastal waters.	Establish state and municipal regulatory framework necessary to prevent introduction of untreated stormwater into tidal and freshwater wetlands by 2010.	
Objective D: To determine trends in designated uses of water bodies.	Increase use of buffers around wetlands in NH coastal watershed.	
Objective E: To determine the status and trends in assemblages of benthic macroinvertebrates.	Determine the extent of groundwater resources and their contaminant load to Great Bay and Hampton Harbor by 2005.	
	Reduce and eliminate groundwater contaminants based on outcome of Objective 1 by 2010.	
	Support completion of state biomonitoring standards and increase the miles of rivers and streams meeting those standards by 2010.	

## RELATIONSHIP TO OTHER MONITORING PROGRAMS

### Existing Monitoring Programs

An abundance of background information, baseline data, and monitoring programs is already available to help determine environmental problems and trends in the New Hampshire Seacoast. Tables 3-5, see pp. 11-33 to 11-35 summarize ongoing monitoring activities in coastal and estuarine New Hampshire that generate or will generate information needed to answer the monitoring questions. Some monitoring and research programs are not included in Tables 3-5, primarily because of geographic scope, small number of sample sites, limited parameters, and/or likelihood of being discontinued in the near future.

### Data/Information Gaps

Gaps in information or data not covered by existing monitoring programs were identified. These information gaps were examined to determine which gaps can realistically be filled within the time and resource limits of the NHEP and its partners. A series of new monitoring activities to be funded with NHEP implementation funds were selected by a committee, based on the relevance of those information gaps to NHEP goals and the economic feasibility of filling the gaps. (See Table 6, p. 11-36.) The NHEP monitoring program will coordinate with existing monitoring efforts, and build on them by collecting data on additional components.

## MONITORING PLAN IMPLEMENTATION

### Data Synthesis and Management

It is necessary to effectively manage the large volume of existing information as well as new information that will be developed through the NHEP monitoring program. Information now exists in multiple formats in a variety of places. Existing monitoring programs are designed to meet the missions of the various implementing organizations. The organizations use different procedures and protocols for data collection, analysis and storage. Coordination of data management among organizations is limited.

In order to measure environmental changes in New Hampshire's estuaries and use that data to manage the quality of the state's estuarine and coastal waters, the NHEP Monitoring Plan establishes a full time Coastal Scientist position to coordinate, synthesize and interpret data.

The position will be funded jointly with the NH Department of Environmental Services (75% NHEP, 25% NH DES), and housed in the NH Department of Environmental Services. This Coastal Scientist position will require the ability to synthesize and integrate data sets related to water quality, shellfish quality, land use, seasons, weather/hydrography, river input, sediment quality, biotic parameters, etc. The goal of the synthesis and integration is to discern status, temporal and spatial trends, relationship, causality, and effects. To support the efforts of the Coastal Scientist, the NHEP will

establish a Technical Advisory Committee, with representatives from NH DES, NH Fish & Game, UNH Jackson Laboratory, CICEET, NHCP, and others.

The Coastal Scientist's management responsibilities for the NHEP monitoring program will include:

- Implement, evaluate, and update the NHEP Monitoring Plan.
- Coordinate coastal environmental quality data collection, management, and interpretation across multiple programs and agencies, and facilitate a technical advisory committee.
- Interpret and synthesize environmental data from numerous sources to accomplish comprehensive assessments and trend analyses of coastal environmental quality, and provide annual reports on findings.
- Design and conduct complex analysis and modeling of water quality data to determine water quality trends, evaluate and allocate pollutant loads, and develop recommendations for watershed-based actions to maintain and improve water quality.

## Monitoring Coordination

The Coastal Scientist will coordinate information generated by both existing and the new/enhanced monitoring activities outlined in the Monitoring Plan. A list of the new monitoring activities that will be initiated through the NHEP monitoring program in 2001 is found in Table 6. Tables 7-12 give a comprehensive view of existing and new monitoring activities by listing: the monitoring component, existing monitoring efforts, identified gaps in monitoring, recommended monitoring activities, new monitoring activities proposed by NHEP, and the responsible party for each existing and new/enhanced monitoring activity, see pp.

A number of steps are required between recording measurements and synthesizing interpreted data.

1. The 'Responsible Party' identified for each monitoring activity in Tables 7-12 will be responsible for management, quality assessment and control, and reporting of data collected, on a schedule and in a format determined by the NHEP Coastal Scientist. Data collected by volunteers will be used.
2. The Coastal Scientist will be responsible for compiling databases from raw data, and archiving the data in an appropriate relational database such as File Maker Pro, Oracle, or Access. NH DES will assist the Coastal Scientist with maintaining data as necessary.
3. The Coastal Scientist will conduct statistical analyses, and make results available in electronic and GIS formats. Analysis will be performed on an ongoing basis, although some time lag is likely between field seasons and analysis.

4. An annual synthesis report to the NHEP Management Conference will include data analysis that incorporates GIS presentation, to the greatest extent possible, and will be used in NHEP program evaluation.
5. Data will be interpreted to inform stakeholders of current conditions and trends. Synthesized products, and potentially raw data, will be made available to the scientific and resource management community electronically on the web. NHEP outreach staff will help communicate interpreted data to the public.

## Monitoring Plan Assessment

Evaluating the effectiveness of the Monitoring Plan is critical to the viability and relevance of the NHEP monitoring strategy. Selection of the new/enhanced monitoring activities to be initiated by NHEP was based on the existence of significant data gaps and the recognition that modifications to the monitoring strategy will be needed as existing and new information is processed, as trends become apparent, or as management needs change.

The success of the monitoring strategy will be assessed in the annual report provided by the Coastal Scientist. In addition, the Monitoring Plan and the monitoring strategy will be assessed every two years as part of the National Estuary Program biennial review process. A comprehensive review of the Monitoring Plan will be conducted by the NHEP and its monitoring partners at a minimum of every five years.

## Monitoring Plan Outline

The NHEP Monitoring Plan is outlined here in six sections: Bacteria and Disease-causing Organisms; Nutrients and Eutrophication; Toxics; Shellfish; Land Use and Habitat Protection; and Critical Species and Habitats. Each section includes:

- Monitoring goal;
- Background description of the issue;
- Monitoring recommendations;
- Specific objectives, indicators, monitoring activities, and timeframe.

Within each section under 'Recommendations' and 'Objectives', monitoring activities are categorized as 'New/Enhanced Monitoring' – for new initiatives coordinated or funded through NHEP, 'Ongoing Monitoring,' – for existing programs, or 'Suggested Monitoring' – for components that could be monitored if additional funds become available or monitoring priorities change.

## SECTION 1: BACTERIA AND DISEASE-CAUSING ORGANISMS

### MONITORING GOAL

Determine the status and trends of the sanitary quality (bacteria and other disease-causing organisms) of shellfish-growing and recreational waters.

### BACKGROUND

Despite reductions of pollution of air, water, and land resources since the first environmental protection legislation was passed in the early 1970s, uses of many surface waters remain restricted, largely due to unacceptable levels of microbial contamination. Because microbial contaminants that can cause disease (pathogens) can be water-borne, exposure to contaminated surface waters is a public health issue.

Water-borne pathogens include a wide variety of bacteria, viruses, protozoan parasites, and other microorganisms. Bacterial and protozoan pathogens can be of human origin, as well as from natural flora and fauna in surface water environments. Human enteric viruses are the suspected cause of most water-borne disease.

Fecal bacteria are found throughout New Hampshire's estuaries, originating from a variety of sources including faulty septic systems, overboard-marine toilet discharges, wastewater treatment facility overflows, and illicit connections between sanitary sewers and stormwater systems. Although coliform (an indicator of fecal bacteria) counts in tidal rivers have declined dramatically since 1960, water quality sampling tracks a pattern of elevated counts from urban runoff and wastewater treatment plants throughout the Great Bay Estuary. Bacterial concentrations in New Hampshire estuaries are highest during or immediately after rainfall, indicating that much of the bacterial pollution comes from contaminated stormwater runoff.

The variety of types and sources of pathogens complicates assessment of the sanitary quality of surface waters. Microbial indicator analysis is the accepted strategy, but no ideal indicator meets all needs. For example, microbial indicators of fecal contamination do not address issues related to nonfecal-borne pathogens. Using a suite of indicators that address different issues is the best sampling and analytical approach.

Important factors in understanding the status and trends of microbial contamination in New Hampshire surface waters include:

- Identification of sources of microbial contaminants;
- Determining the fate of contaminants as affected by seasonal factors such as rainfall frequency, evapo-transpiration, migratory bird presence, wind speed and direction, temperature, tidal exposure, algal blooms, activities of indigenous organisms, regrowth of pathogens and indicators, and sunlight;

- The relationships between microbial fecal indicators and pathogens, and between fecal indicators and non-fecal pathogens;
- The relationship between human health risks and concentrations or incidence of pathogens and indicators.

## **RECOMMENDATIONS FOR MONITORING FOR BACTERIA**

Existing monitoring programs incorporate much of what is needed to classify all coastal waters for shellfish harvesting and recreational uses. However, a comprehensive program requires additional measurements of some indicators, increased frequency of sampling for some programs, and some expansion of sites.

### **New/Enhanced Monitoring**

The existing Seacoast-wide routine monitoring for fecal coliforms by the NH DES will be continued, but will include analyses for *Escherichia coli* in some freshwater sites with financial assistance from NHEP.

A routine monitoring program involving microbial source tracking will be initiated in the major coastal areas of New Hampshire with financial assistance from NHEP, and will include more intensive pollution source identification studies.

### **Suggested Monitoring**

Periodic (seasonal) assessments of New Hampshire coastal waters for microbial pathogens, including viruses, fecal-borne bacteria, indigenous bacterial pathogens, and algal biotoxin-producing species should be initiated when resources are available.

Events associated with potentially more severe microbial contamination – including storm/runoff events, WWTF failures, warm weather-associated acceleration of indigenous bacterial and toxin-producing algal growth, and high-density bather populations at coastal beaches, should be monitored as resources are available.

## MONITORING OBJECTIVES FOR BACTERIA

### Monitoring

Objective 1A: To determine if concentrations of fecal-borne microbial contaminants are increasing with time.

Indicators: Fecal Coliform, Enterococci and *Escherichia coli* are well-established indicators of fecal contamination and are designated state standards for classifying different types of coastal waters. Both fecal coliforms and enterococci should be measured in tidal waters, and *E. coli* measured in freshwater areas of coastal watersheds.

### New/Enhanced

Monitoring: NH DES will restructure both its freshwater and saltwater ambient sampling programs to include fecal coliform and *E. coli* at additional sites. Existing monthly programs provide the spatial intensity necessary to classify most coastal waters, but new sites may be needed in freshwater tributaries.

Initiate: 2001

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### Monitoring

Objective 1B: To determine the effects of human-borne fecal microbial contaminants on surface water quality in coastal New Hampshire.

Indicator: *Escherichia coli*

### New/Enhanced

Monitoring: Microbial source tracking will differentiate between human and non-human sources of bacteria. Monthly sampling as conducted for Objective A can provide samples. DNA source tracking will identify pathogen origin and assist management decisions regarding pollution source identification and elimination.

Initiate: 2001

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### Monitoring

Objective 1C: To determine if the incidence and concentrations of microbial pathogens are changing with time.

Indicators: Bacterial, viral, protozoan, and algal pathogens

### Suggested

Monitoring: Seasonal sampling (4 times/year) in areas of highest concern to establish baseline of incidence and concentration. Supplemental sampling to target events (heavy rainfall/runoff, WWTF failure, high densities of bathers at beaches, warm weather for vibrios).

Initiate: To be determined

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## SECTION 2: NUTRIENTS AND EUTROPHICATION

### MONITORING GOAL

Determine the status and trends of eutrophic conditions in New Hampshire coastal and estuarine waters.

### BACKGROUND

Nutrient-driven eutrophication is one of the major agents of ecosystem alteration in shallow estuarine and coastal areas. Indicators of eutrophic conditions include high concentrations of phytoplankton (measured by high concentrations of chlorophyll *a*) and associated turbidity; high abundance of epiphytic algal growth on submerged aquatic vegetation; proliferation of nuisance or opportunistic macroalgae; and elevated concentrations of water column nutrients.

As concentration or abundance of these indicators increases, submerged aquatic vegetation can be lost due to shading by suspended particulates and epiphytes. Depressed dissolved oxygen (hypoxia and anoxia) results from the dark phase respiration and decay of phytoplankton and macroalgae. Hypoxia and anoxia can have serious consequences for highly valued estuarine biota, and can impair human uses such as fishing, shellfishing, swimming, and boating.

Indicators of eutrophication in New Hampshire's estuarine and coastal areas have been monitored at varying degrees of spatial and temporal coverage and continuity since the early 1970s. Review of the data related to nutrient-driven eutrophication indicates that the Great Bay Estuary exhibits moderate symptoms of eutrophication in limited geographic areas. The limited amount of data available for Hampton-Seabrook Harbor, Little Harbor and Rye Harbor and the Atlantic coast, indicates no expression of eutrophic conditions at any of those locations at the present time.

With the population of the New Hampshire Seacoast growing rapidly, nutrient loading can be expected to increase and conditions worsen. However, measures to reduce nutrient inputs—such as nitrogen and phosphorus removal from municipal wastewater, installation of stormwater Best Management Practices, and advanced technologies for on-site treatment—could improve conditions. A properly designed comprehensive monitoring program will detect changes in both directions.

### MONITORING RECOMMENDATIONS

An effective monitoring program for nutrient-driven eutrophication should include spatial and/or temporal expansion of some existing programs, continuation of others that have expired or will expire, and initiation of some new activities.

## **New/Enhanced Monitoring**

The Great Bay National Estuarine Research Reserve (GBNERR) monthly sampling and analysis for nutrients, chlorophyll, total suspended solids, and particulate organic matter will be expanded spatially with financial assistance from NHEP. The expanded program will be coordinated with NH DES monthly ancillary sampling at selected shellfish monitoring sites in Great Bay, Hampton and Little harbors, with analyses performed by UNH JEL or NH DES. All samples will also be measured for dissolved inorganic nitrogen.

The NH DES ambient program will be enhanced to provide at least monthly data on dissolved oxygen at critical freshwater sites with financial assistance from NHEP.

## **Ongoing Monitoring**

The GBNERR continuous in-situ monitoring will be continued, with some financial assistance from NHEP for operations and maintenance. Because these monitoring stations are the only source of high temporal-intensity data for dissolved oxygen, chlorophyll a, temperature, salinity, pH and turbidity, they are the only way to effectively monitor frequency and duration of phytoplankton blooms and depressed oxygen conditions.

The Great Bay Coast Watch program should continue, and after a review of sampling sites, possibly add more measurements.

Sampling sites at the 18 National Pollution Discharge Elimination System (NPDES) permitted wastewater treatment plants.

## **Suggested Monitoring**

In-situ monitoring could be enhanced by expanding the UNH/NOAA Cooperative Institute for Coastal and Estuarine Environmental Technology (CICEET) Remote Contaminant Monitoring System (RECOMS) project. Additional instruments may be added as funds are available for purchase and maintenance.

The NPDES program should be enhanced by requiring weekly sampling for biological oxygen demand and nutrients (nitrogen and phosphorus) at the 18 wastewater treatment plants in the coastal watershed. This will provide accurate data on point source nutrient loading, which has been determined to contribute more than 40% of the nitrogen input to Great Bay. This activity may be undertaken during the next permit cycle.

Airborne remote sensing and image analysis to measure macroalgae and eelgrass should be conducted annually as resources are available. Cooperative efforts can be pursued with the NH Coastal Program, CICEET, and aircraft of opportunity (e.g., NOAA Coastal Geodetic Survey) to acquire images.

## MONITORING OBJECTIVES FOR NUTRIENTS

### Monitoring

Objective 2A: To determine whether concentrations of dissolved and particulate nutrients are increasing as Seacoast region development and population increases.

Indicators: Dissolved nutrients (high priority), particulate nitrogen and particulate phosphorous (lower priority).

### New/Enhanced

Monitoring: A) NHDES will restructure both its freshwater and saltwater ambient sampling programs to address additional parameters and spatial coverage. Additional sites for the above indicators will be sampled in the Oyster, Bellamy, and upper Piscataqua rivers, southeast Great Bay, and upper Little Bay by the NH DES shellfish and ambient programs. Existing sampling sites will be used in Hampton and Little harbors.  
B) NHEP will contribute funds for ongoing operation and maintenance expenses of the in-situ, real-time data loggers.

Initiate: 2001

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### Monitoring

Objective 2B: To determine whether concentrations of phytoplankton (as measured by chlorophyll a) in NH tidal waters change over time.

Indicators: Chlorophyll a

### New/Enhanced

Monitoring: A) NH DES ambient and shellfish programs will collect samples for Chlorophyll a on the restructured sampling regime used for bacteria and nutrients. Monitoring stations will be established in Hampton and Little harbors, and the spatial array of stations expanded in Great Bay to develop baseline data.  
B) Support for in-situ data loggers will provide another source of data on chlorophyll a.

Initiate: 2001

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### Monitoring

Objective 2C: To determine whether concentrations of suspended particulates (as measured by total suspended solids and particulate organic matter, turbidity, and secchi depth) in NH tidal waters change over time.

Indicators: Total suspended solids (TSS), particulate organic matter, and turbidity

### New/Enhanced

Monitoring: TSS will be added to the restructured NH DES monitoring

program for saltwater stations, including establishing monitoring stations in Hampton and Little harbors and expanding spatial array of stations in Great Bay. Existing baselines can be used to determine changes in concentrations resulting from no action, or from implementation of reduction measures.

Initiate: 2001

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Monitoring

Objective 2D: To determine whether the concentration of dissolved oxygen and percent oxygen saturation in NH tidal waters change over time.

Indicators: Dissolved oxygen, biological oxygen demand

New Enhanced

Monitoring: BOD will be added to the restructured DES monitoring effort for freshwater stations and DO sampling continued in both fresh and salt water monitoring. Establish monitoring stations in Hampton and Little harbors; expand spatial array of stations in Great Bay to develop baseline data. Compare data with benchmarks for hypoxia, anoxia, and biologically critical saturation percentage.

Initiate: 2001

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Monitoring

Objective 2E: To determine whether nuisance macroalgae (opportunistic green algae) increase in abundance and area in intertidal and shallow subtidal areas of the NH estuaries.

Indicator: Macroalgae

Suggested

Monitoring: Establish baselines for entire Great Bay Estuary, Hampton-Seabrook Harbor, and Little Harbor using aerial imaging.

Initiate: To be determined

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Monitoring

Objective 2F: To determine whether eelgrass decreases in abundance (density and biomass) and area in intertidal and shallow subtidal areas of NH estuaries.

Indicator: Eelgrass

Suggested

Monitoring: Establish baseline of geo-spatial cover for tidal tributaries, Little Bay, Piscataqua River, Portsmouth Harbor and Back Channel area, and Little Harbor, using aerial imaging

Initiate: To be determined

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## SECTION 3: TOXIC CONTAMINANTS

### MONITORING GOAL

To determine the status and trends of toxic contaminants in water, sediment, and biota of coastal New Hampshire.

### BACKGROUND

Despite significant reductions in pollution of air, water, and land resources since the early 1970s, many contaminants persist in the environment.

Historical pollution combined with present-day contamination results in exposure of humans and other biota to a variety of toxic contaminants in marine and estuarine environments. Contaminants that persist and accumulate in ecosystems are of special concern, since even low-level chronic exposure to some of these chemicals can cause toxic effects.

A wide range of toxic contaminants are of concern, including inorganic (trace and heavy metals) and organic contaminants. Toxic inorganic contaminants include a wide range of chemicals—mostly either exclusively human-made or produced in much greater quantities through human activities—that are not susceptible to breakdown, and persist in the environment. Biological and chemical processes can change the forms of these contaminants and affect their toxicity, availability, and mobility in the environment.

Although virtually all organic compounds are susceptible to breakdown by microorganisms, many toxic organic compounds persist in marine and estuarine ecosystems where conditions limit these processes. Persistent toxic organic compounds of concern in the marine environment include polychlorinated biphenyls (PCB), polyaromatic hydrocarbons (PAH), and chlorinated pesticides.

The many types, sources, and sinks of toxic contaminants present a challenge for environmental assessments in coastal surface waters. No single indicator can take the place of analyzing samples for the full range of contaminants. The high cost of initial analyses to determine the presence of toxic contaminants often limits further studies needed to determine toxic effects once the presence and concentrations of toxic contaminants have been assessed for sediments, water, and biota.

### MONITORING RECOMMENDATIONS FOR TOXIC CONTAMINANTS

#### New/Enhanced Monitoring

Soft-shell clams and oysters will be monitored for toxic contaminants with financial assistance from NHEP. Sampling will rotate between beds, and compared to mussel data from the Gulfwatch program.

Monitoring of predatory fish for toxic contaminants will be researched in 2001 and implemented thereafter with financial assistance from NHEP.

#### Suggested Monitoring

Include monitoring for effects of toxic contaminants on marine and estuarine biota in existing programs that measure bio-exposure, to complement and

augment those measurements. Continue sediment toxicity assays using model organisms (Coastal 2000), and expand assays to target shellfish and higher trophic-level species.

Continue existing monitoring programs, including Coastal 2000 and Gulfwatch, beyond currently planned schedules which end after 2001. Annual sampling of a subset of sites rotated on a 3-year basis is recommended for monitoring of sediments and blue mussels.

Modify existing programs to allow for iterative pollution source identification monitoring.

## MONITORING OBJECTIVES FOR TOXICS

### Monitoring

Objective 3A: To determine if toxic contaminant concentrations in seafood species from NH coastal waters are increasing with time.

Indicators: Inorganic (trace and heavy metals) and organic contaminants

### New/Enhanced

Monitoring: A) Oysters and clams will be tested for contaminant exposure as part of the NHEP Monitoring Program. Sampling will be annual at a different subset of sites with a three-year rotation for revisiting sites in order to develop temporal trend analysis. B) Monitoring of toxic contaminant exposure in predatory fish will be researched and implemented.

Initiate: 2001

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### Monitoring

Objective 3B: To determine if concentrations of toxic contaminants in sediments, water, and biota are increasing with time.

Indicators: Inorganic (trace and heavy metals) and organic contaminants

### Suggested

Monitoring: Fish and shellfish (biota), water, and sediment sampled annually and compared with previous sampling results over time.

Initiate: To be determined.

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### Monitoring

Objective 3C: To determine if toxic contaminants are causing increasingly prevalent toxic effects in marine and estuarine biota.

Indicators: Inorganic (trace and heavy metals) and organic contaminants

### Suggested

Monitoring: Use Coastal 2000 sampling sites for sediment toxicity to determine temporal toxicity trends for sediments. Compare survival in toxic sediments and control sediments to determine mortality rates.

Initiate: To be determined.

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## SECTION 4: SHELLFISH POPULATIONS

### MONITORING GOAL

Determine the status and trends of shellfish populations in New Hampshire's coastal and estuarine waters.

### BACKGROUND

The estuaries and coastal areas of New Hampshire are ideal habitat for a number of molluscan shellfish species. The Great Bay Estuary, including Little Harbor and the Back Channel area, supports populations of the eastern oyster (*Crassostrea virginica*), the European flat or Belon oyster (*Ostrea edulis*), softshell clam (*Mya arenaria*), the blue mussel (*Mytilus edulis*), the razor clam (*Ensis directus*), and the sea scallop (*Placopecten magellanicus*). Hampton-Seabrook Harbor supports abundant populations of the softshell clam and intertidal populations of the blue mussel. Near-shore coastal areas support populations of surf clams (*Spisula solidissima*), ocean quahogs (*Arctica islandica*), and blue mussels.

Molluscan shellfish in New Hampshire's estuarine and coastal areas are economically important because they support important recreational fisheries and have tremendous potential as aquaculture species. They are excellent bio-indicators of estuarine condition because they are relatively long-lived, and integrate their environment over time. As filter-feeders, they play an important role in nutrient-cycling, improving water clarity, and removing significant quantities of nitrogen and phosphorus from the water column by consuming phytoplankton and organic detritus.

Bottom-dwelling shellfish such as mussels, oysters, and scallops provide valuable habitat for rich assemblages of invertebrates and fish, while large infaunal bivalves oxygenate soft sediments with their burrowing activities. Many estuarine ecologists consider oysters a 'keystone species,' and oyster beds in temperate estuaries are considered the equivalent of coral reefs in tropical seas. Many studies have shown that species density, diversity, and biomass are significantly greater in oyster beds than on equivalent bottom without oysters.

Effective management of these ecologically and economically important shellfish resources requires an understanding of the geographic location of the resource, population size and structure, coverage area, habitat condition, harvest pressure, and other factors that influence shellfish populations.

Molluscan shellfish abundance and population structure have been surveyed with varying degrees of consistency and thoroughness over the past several decades. With a few exceptions, such as softshell clams in Hampton-Seabrook Harbor, most databases are inadequate in temporal and spatial scale to determine current status or predict trends. Little or no data are available for some species.

Recent and reliable data are available for oysters in Great Bay and softshell clams in Hampton-Seabrook Harbor. Oyster populations in the Great Bay Estuary declined dramatically in the past decade. Clam populations in

Hampton-Seabrook Harbor have recovered from their mid-to-late 1980s decline, and have been stable for the past few years. Recent interest by commercial fishermen in the harvest of surf clams and ocean quahogs in near-shore coastal areas has alerted resource managers to the need to gather basic population data for these species.

Important shellfish monitoring needs include:

- \* Continued monitoring of clam and oyster populations;
- \* Monitoring of harvest pressure, predation, disease, and environmental factors that affect populations;
- \* Gathering baseline information on species for which there is little or no information.

## **MONITORING RECOMMENDATIONS FOR SHELLFISH**

### **New/Enhanced Monitoring**

Oyster and clam population studies will be conducted on an established schedule with financial assistance from NHEP, so that each major bed is sampled at minimum every three years. The sampling program will include a determination of bed acreage at each sampling.

Disease testing for MSX and Dermo in oysters will continue annually with financial assistance from NHEP.

Restoration monitoring will be implemented for any shellfish restoration efforts funded by NHEP. Restoration success must be clearly documented, and results distributed to appropriate parties.

### **Ongoing Monitoring**

Normandeau Associates Inc. (NAI)/Seabrook Station monitoring program in Hampton-Seabrook Harbor for softshell clam populations, clam disease, green crab abundance, and mussel settlement should be continued.

### **Suggested Future Monitoring**

Additional clam abundance monitoring sites in the Hampton-Seabrook Harbor tributaries, Great Bay, and Little Harbor should be conducted on an established schedule by NH Fish and Game or another qualified entity using the methods employed by NAI as resources are available.

Methods for determining harvest pressure should be formalized, and evaluated for effectiveness annually. Recreational harvesters could contribute significantly to this monitoring goal by providing valuable information on the amount of shellfish harvested, and on the presence of predatory snails on the state's most popular oyster beds.

If a commercial fishery commences, population studies should be initiated for sea scallops, and for surf clams and ocean quahogs

Additional sites for green crab trapping and clam disease diagnostics in Great Bay and Little Harbor should be monitored as resources are available.



## MONITORING OBJECTIVES FOR SHELLFISH

### Monitoring

Objective 4A: To determine whether the abundance and population structure of molluscan shellfish in New Hampshire's estuarine and coastal areas change over time.

Indicators: Eastern Oysters, softshell clams, surf clams, ocean quahogs, sea scallops, and blue mussels

### New/Enhanced

Monitoring: A) Rotational sampling every three years of oyster and clam beds for spatial dimensions, density, and population structure.  
B) Develop map of oyster and clam bed acreage annually.

Initiate: 2001

### Suggested

Monitoring: Various techniques to determine location and acreage of surf clams, quahogs, sea scallops, and blue mussels. Conduct surveys of beds annually for most species to determine density and size distribution.

Initiate: To be determined.

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### Monitoring

Objective 4B: To determine the status and trends of shellfish diseases.

Indicators: MSX and Dermo for Eastern oysters, and Sarcomastic Neoplasia for softshell clams

### NHEP

Monitoring: Oysters will be collected from 5 beds annually and analyzed for percentage occurrence, intensity levels, and mortalities attributed to MSX and Dermo

Initiate: 2001 (ongoing since 1997)

### Suggested

Monitoring: Clams will be collected annually and analyzed for disease.

Initiate: To be determined

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Monitoring  
Objective 4C: To determine how much (bushels, pounds, # of individuals) of each species of molluscan shellfish is harvested from NH waters.

Indicators: Eastern Oysters, softshell clams, surf clams, ocean quahogs, sea scallops, and blue mussels

Suggested  
Monitoring: Formalize methods for determining harvest pressure, such as voluntary reporting by recreational harvesters and required reporting for commercial license holders (when applicable).

Initiate: To be determined.

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Monitoring  
Objective 4D: To determine the effects of predation on shellfish populations in NH tidal waters.

Indicators: Green crabs (*Carcinus maenus*), and oyster drills (*Urosalpinx cinerea*)

Ongoing  
Monitoring: Continue twice monthly sampling of green crabs in Hampton-Seabrook Harbor and initiate two sampling locations in Great Bay for green crabs.

Suggested  
Monitoring: Establish a voluntary observational and reporting programs for oyster drills involving recreational oyster harvesters at the Nannie Island and Adams Point oyster beds.

Initiate: To be determined

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Monitoring  
Objective 4E: To determine the effect of restoration on shellfish populations in NH tidal waters.

Indicators: Shellfish species at an identified restoration site

Suggested  
Monitoring: Select appropriate restoration sites which historically supported shellfish species, where the cause for absence of the resource is known and no longer exists, and where suitable environmental conditions exist. Utilize abundance measurements as detailed in Objective A to monitor species abundance over time.

Initiate: As NHEP funds are applied to shellfish restoration projects.

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## **SECTION 5: LAND USE, DEVELOPMENT, AND HABITAT PROTECTION**

### **MONITORING GOAL**

Determine the status and trends of land use, development, and habitat protection in coastal New Hampshire

### **BACKGROUND**

The Seacoast region of New Hampshire has a long history as an important center of commerce and industry in the state and region. The economy of the Seacoast is currently prospering, with high employment, and new development to accommodate housing needs and services is booming. The pleasing aesthetics of natural coastal scenery and a clean environment are part of what draws people to live in the Seacoast. As population and development have increased, so have expectations for improved water quality and safety of recreational waters. Yet increased population and development are almost inevitably accompanied by increased pollution, and habitat fragmentation and degradation. Marine resource-based industries depend on a clean environment, and are also a vital part of the local economy. Land use, development, and habitat protection are issues of increasing concern in the Seacoast.

Settlement of towns and cities, and clearing of forests for timber and to produce food, began the changes of land use in the Seacoast region. Road construction further fragmented habitat. Automobiles, the state highway system, and the Interstate Highway Act resulted in further fragmentation of forests and habitat, and opened more areas of the Seacoast to development. Human population and land development in the Seacoast have increased rapidly over the last 40 years. Increased stormwater runoff associated with increases in impervious surfaces from development are degrading water and habitat quality in the Seacoast. Development is also fragmenting habitat. Shoreline development has diminished the aesthetics and water quality of many areas, and drinking water supplies are running short.

Developable land is at a premium in the region, and development of areas outside urban centers has accelerated problems associated with sprawl. The costs of sprawl development include redundant infrastructure, more roads and impervious surfaces, longer service routes for emergency vehicles, etc., and growing needs for pollution control. Sprawl generally results in the decline of older cities and town centers, habitat fragmentation, increased taxes, and increased transportation costs for family budgets. For all these reasons, planning for further development should incorporate prevention of further environmental degradation, and protection of important habitats.

An effective land use, development, and habitat protection monitoring program requires:

- Annual updates of existing databases;
- Analysis of the data to assess rates of change in sprawl development;
- Analysis of the data to assess rates of change in impervious surface acreage;
- Analysis of the data to assess rates of change in habitat protection.

## RECOMMENDED MONITORING FOR LAND USE

### New/Enhanced Monitoring

Conduct Needs Assessment to research methods for monitoring land use change and develop recommendations for potential monitoring actions.

### Suggested Monitoring

One agency, such as the UNH Complex Systems Research Center, should serve as a center for compiling all relevant data on human population, land use acreage changes, aerial and satellite imagery, housing construction, average forest patch size, etc.

Update land use change information annually for all coastal communities, and report results back to the municipalities.

Integrate data needed to assess impervious surface area and sprawl.

## MONITORING OBJECTIVES FOR LAND USE

### Monitoring

Objective 5A: To determine if the rate of land use change increases as human population and development increase in coastal New Hampshire.

Indicators: Impervious area; human population; acreage of developed land

### Suggested

Monitoring: Annual update of UNH/CSRS GIS data on land use and cover, using aerial and satellite imagery of all coastal municipalities and data from regional planning commission analyses of land use in specific municipalities. Include NH OSP data on human population changes in municipalities.

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Monitoring  
Objective 5B: To determine if acreage of permanently protected important habitats increases as human population and development increase in coastal New Hampshire.

Indicators: Acreage of protected habitats; human population; acreage of developed land; average forest patch size; road density/road kills

Suggested  
Monitoring: Annual updating of UNH Complex Systems Research Center (CSRC) GIS data on land use and cover, using data from regional planning commission analyses of land use in specific municipalities and land protection organizations. Include data from NH OSP on changes in human population in coastal municipalities and Society for Protection of NH Forests (SPNHF) analyses of forest patch size.

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Monitoring  
Objective 5C: To determine if the rate of sprawl increases as human population and development increase in coastal New Hampshire.

Indicators: Distance of residences from schools, police, fire, public water supply; human population; acreage of developed land; residential housing construction; average forest patch size

Suggested  
Monitoring: Annual updating of UNH/CSRS GIS data on land use, land cover, and municipal service locations, using data from regional planning commission analyses of land use in specific municipalities, residential housing construction, and SPNHF analyses of forest patch size.

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## SECTION 6: CRITICAL SPECIES AND HABITATS

### MONITORING GOAL

To determine the status and trends of critical species and habitats in New Hampshire coastal and estuarine watersheds.

### BACKGROUND

Habitat is the setting in which plants or animals feed, find shelter, and reproduce. Plants and animals need specific types and quality of habitat to meet their particular needs. New Hampshire's estuaries and the surrounding upland regions provide a wealth of unique and productive habitats that support a diverse array of plant and animal populations, including threatened and endangered species.

The key to maintaining these diverse assemblages of species is protecting and restoring appropriate habitats. Pollution, impacts from development, and inappropriate human disturbances can degrade, fragment, and destroy habitat, as well as alter species composition. The location and extent of critical habitats must be ascertained, and consistent methods used to monitor change over time. Identifying plant and animal species that are indicators of habitat and overall ecosystem condition is important to assessing habitat trends.

A balance must be struck between human activities and protecting and restoring natural communities. Participants in the NHEP identified tidal and freshwater wetlands, shellfish habitat, shorelands and streambanks, and anadromous fish habitats as the highest priorities for protection and restoration. A review of existing monitoring and restoration activities found many programs that monitor some aspect of all the identified critical habitats.

A few gaps were identified, but this review showed that efforts to protect and restore critical species and habitats would benefit from:

- Better integration of the data collected by the diverse groups involved in monitoring, and
- Rigorous synthesis and widespread dissemination of the information.

### RECOMMENDED MONITORING FOR CRITICAL SPECIES AND HABITATS

An effective program to monitor changes in critical species and habitats requires a few new activities. However, improving coordination, management, integration, and synthesis of the data generated by existing programs will be the major emphasis for monitoring critical species and habitats.

#### Enhanced Monitoring

Analysis of monitoring data will include creating relational databases with appropriate data collected by various monitoring activities. The Coastal Scientist funded by NHEP and NH DES will lead this activity.



## Suggested Future Monitoring

Collect additional data on wetlands acreage and condition through use of opportunistic overflights and tracking by municipalities and the Regional Planning Commissions. Integrate all new data collected or generated into the Granit geospatial database.

Review benthic data generated by Coastal 2000 to determine whether the sites sampled for this program provide data that will enhance the overall understanding of benthic communities.

Initiate long-term monitoring of reptile and amphibian populations. Likely parties to be involved in such a program include EPA, Audubon Society of NH, NH Fish and Game, and the University of New Hampshire.

Review groundwater data generated by research and drinking water programs to identify issues and locations of concern. A monitoring program may need to be developed depending on the outcome of this review. This activity is associated with Action Plans, Land 18 and 19 in the NHEP Management Plan.

Determine the rate of increase in invasive wetlands plant species, particularly Phragmites. This information may be extracted from aerial imagery with the proper groundtruthing.

## MONITORING OBJECTIVES FOR CRITICAL SPECIES AND HABITAT

### Monitoring

Objective 6A: To determine trends in wetland degradation and restoration.

Indicators: Plant species, fish usage, hydrology and acreage (tidal and freshwater)

### Suggested

Monitoring: Encourage continuation of existing monitoring programs; increased monitoring by towns and RPCs to map small wetlands; and take advantage of overflights for other purposes to update wetlands maps. Encourage NH DES to follow up on permits.

Initiate: To be determined

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Monitoring Objective 6B:	To determine whether populations of resident and migratory finfish species change over time.
Indicators:	Anadromous fish, estuarine and coastal fish assemblages, game fish, and commercial species
Suggested Monitoring:	No new sampling activities recommended. Better data management, integration, synthesis, and reporting are needed. Create and analyze relational databases that integrate fish data with water quality and habitat information. Coordinated by Coastal Scientist.
Initiate:	To be determined
Monitoring Objective 6C:	To determine the quantity and quality of groundwater entering estuarine and coastal waters.
Indicators:	Groundwater quantity and quality
Suggested Monitoring:	No new sampling recommended at this time. All existing groundwater data generated from drinking water wells and research programs should be comprehensively reviewed to determine what types of monitoring activities are needed.
Initiate:	To be determined.
Monitoring Objective 6D:	To determine the trends in designated uses of waterbodies.
Indicators:	Specific indicators vary, but include bacterial indicators, tissue concentrations of toxic substances, turbidity, chlorophyll concentrations, and dissolved oxygen
Suggested Monitoring:	Continue inventory development for the 305 B reports
Initiate:	Ongoing

Monitoring  
Objective 6E: To determine the status and trends in assemblages of benthic macroinvertebrates.

Indicator: Benthic community structure, abundance of juvenile lobsters, horseshoe crabs

Suggested Monitoring: Encourage continuation of existing programs, and improve data management, integration, synthesis, and reporting. Create and analyze relational databases that integrate invertebrate data with water quality and habitat information. Select several Coastal 2000 sites for continued annual monitoring after the program ends in 2001. Increase the frequency of NH DES stream biomonitoring.

Initiate: To be determined.

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Monitoring  
Objective 6F: To determine the status and trends in wildlife populations.

Indicator: Abundance of shorebirds, waterfowl, mammals, eagles, reptiles and amphibians.

Suggested Monitoring: Continue existing bird and mammal programs and improve data management, integration, synthesis, and reporting. Create and analyze relational databases. Initiate long-term monitoring program for reptiles and amphibians.

Initiate: To be determined.

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Monitoring  
Objective 6G: To determine the status and trends of invasive wetland plant species.

Indicator: Acreage of Phragmites in salt marshes; amount of purple loosestrife in wetlands

Suggested Monitoring: Use available aerial imagery and seek new imagery. Conduct ground-truthing.

Initiate: To be determined.

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**Table 3: Pollution Monitoring Programs in Coastal New Hampshire**

Program	Parameters	Frequency of Monitoring	Number of Sampling Sites	General Area Sampled	Comments
NH DES Ambient Program	<i>E. coli</i> , D.O., metals, temp., pH, conductivity	3 samples/station for most parameters	typically 40-50 stations in coastal watershed	Coastal watersheds (fresh-water only)	Samples not collected every year (done on watershed-rotation)
NH DES Shellfish Water (Routine) Program	fecal coliform, temp., salinity, pH	monthly, 9-12 samples/yr	60-75 sites	All tidal waters	
NH DES Shellfish Water (Ancillary) Program	TSS, % organic, DO, chlorophyll a nitrate	monthly, Apr-Oct	8 sites	Great Bay Estuary, Hampton-Seabrook Harbor	
NH DES Tidal Beach Program	enterococci	3 samp./visit; weekly visits (July-Aug)	9 beaches	Atlantic Coastal beaches	
NH DES Beach Program	<i>E. coli</i>	3 samp./visit; weekly visits (July-Aug)	9 beaches	Coastal watershed	
NH DES, NH F&G PSP/Red Tide Program	PSP toxin in mussel tissue	1-2 times/wk, Apr-Oct	1 site	Atlantic Coastal Water	Site located near Hampton-Seabrook Harbor
NH DES, UNH/JEL GulfWatch Program	heavy metals, toxic organics in mussel tissue	1 sample per 3 yrs (6-7 sites per year)	20 sites	Great Bay Estuary, Rye Harbor, Hampton-Seabrook Harbor	
NPDES Permit Monitoring	Varies by permit. Usually BOD5, TSS, chlorine, bacteria, pH, whole effluent toxicity (WET); sometimes metals, nutrients.	Varies with permit. Typically one effluent sample/week for most parameters.	18 municipal and 13 industrial WWTFs in the coastal watershed	Coastal Watershed	NHDES inspectors inspect the WWTFs each year and sample them at least once every 5 years for most parameters.
NH DES Groundwater Quality (Water Supply) Monitoring	nitrogen, VOC, pesticides, metals, radiological, pH, bacteria	variable; 1 samp/month, quarter, year, 3 yrs, or 6 yrs	289 wells (does not include "transient systems")	Coastal Watershed	Approx. 40% run tests after corrosion treatment; some water samples blended from multiple wells
GBNERR, UNH/JEL, NHCP Ambient Program	salinity, temp., pH, TSS, bacteria, nutrients, D.O., chlorophyll a	2 samples per month (H and L tide)	4 sites	Great Bay Estuary	Sites in Squamscott, Lamprey, Piscataqua Rivers, and Adams Point
GBNERR/JEL Datalogger Program	salinity, depth, conduct., temp., pH, turbidity, D.O., chlor a	30 min interval, non-winter months	2 sites (Great Bay and Squamscott River)	Great Bay Estuary	Instruments removed periodically for servicing
CICEET Datalogger Program	salinity, depth, conduct., pH, turbidity, DO, chlorophylla	30 min interval, non-winter months	1 site (Lamprey River)	Great Bay Estuary	2 additional sites to be added in Oyster and Bellamy Rivers
CICEET Nutrient Monitoring	dissolved nutrients	variable	3 sites (Oyster, Salmon Falls, Lamprey, rivers)	Great Bay Estuary	3 year project to end in summer of 2000
Great Bay Watch (Base Program)	fecal coliform, temp., salinity, pH, D.O., secchi	high/low tide sampling twice/month, April-Nov.	20 sites	Great Bay Estuary	
PNSY Sampling Program	metals, PAHs, PCBs, dioxin, pesticides	bimonthly	—	Great Bay Estuary (Portsmouth Harbor only)	Sediment, mussels, juvenile lobsters sampled
NHCP Marine Debris Program	marine debris	annual cleanup	25-30 sites	All tidal waters	Results of debris type and tonnage tracked each year
UNH Atmospheric Deposition Monitoring	mercury (wet & dry), other metals, aerosol nitrogen	variable (some continuous monitoring)	1 site	Coastal NH	Site at USCG station, New Castle, NH
Coastal 2000 Program	WQ, sediment & tissue toxicity, fish populations, habitat indicators	one sample	up to 50 sites	Great Bay Estuary, Hampton-Seabrook Harbor	One-time sampling (to begin summer of 2000) to establish baseline conditions
NH Open Ocean Aquaculture Datalogger	temp, salinity, depth, turbidity, currents	continuous	1 site, 2 depths	Atlantic Ocean	
UNH Open Ocean Aquaculture Water Program	nutrients, TSS & % organic, chlorophyll a	monthly at 2 depths	3 sites	Atlantic Ocean	

**Table 4: Finfish and Shellfish Resource Monitoring Programs in Coastal New Hampshire.**

Program	Parameters	Frequency of Monitoring	Number of Sampling Sites	General Area Sampled	Comments
GBNERR/JEL Estuarine Resource Program	variety of estuarine resources	annual program	variable; dependent on parameter	Great Bay Estuary	Shellfish, macroalgae, eelgrass, plankton, etc. on annual-rotating basis
NH F&G Oyster Disease Testing	MSX and Dermo	1 sample per year	4 sites	Great Bay Estuary	Sites at Adams Pt, Nannie Island, Pisc. and Squamscott Rivers
NH F&G Shellfish Harvest Survey	recreational clam and oyster harvest	sporadic for oysters	Hampton Harbor (clams)	Great Bay Estuary; Hampton Harbor	Oyster info collected via mail survey; clam info by count of harvesters on selected days
NH F&G Oyster Resource Program	Oyster density, spatfall, size	annually Oct-Nov	6 sites	Great Bay Estuary	By SCUBA; sites at Pisc. River (Sprague Cove), Ports. Harbor (Peirce Is.), and New Castle
NH F&G Juvenile Lobster Survey	juvenile lobster	monthly, Apr to Jan	3 sites	Great Bay Estuary; Coastal water	By SCUBA; sites at Adams Pt, Woodman Pt., Nannie Island, Pisc. and Squamscott Rivers
NH F&G Lobster Sea Sampling Program	lobster	monthly, Jun-Oct	2 sites	Pisc. River and Atlantic Ocean	Sites in Piscataqua River and at Isles of Shoals
NH F&G Estuarine Juvenile Fish Survey	winter flounder, river herring, shad	monthly Jun-Nov	10 in GBE, 4 in Hampton Harbor	Great Bay Estuary, Hampton Harbor	Seine hauls
NH F&G Coastal Shad Restoration Program	shad (counts of returning adult spawning shad)	daily Apr-June	1 site (Exeter River fish ladder)	Great Bay Estuary	
NH F&G River Herring Restoration Program	herring (counts of returning adult spawning fish)	daily during spring runs	6 rivers	Great Bay Estuary, Hampton Harbor	Sites in Cocheco, Exeter, Lamprey, Oyster, Taylor and Winnicut Rivers
NH F&G Atl. Salmon Restoration Program	salmon	spring - fall	Cocheco and Lamprey Rivers	Great Bay Estuary	Adults trapped at fish ladders spring & fall; electrofishing to evaluate growth in fall
NH F&G Sea Run Trout Creel Surveys	sea run brown trout harvest	during fishing season	N/A	Berrys Brook	Done by mail/survey card
NH F&G Striped Bass Creel Surveys	striped bass harvest	during fishing season	N/A	All Tidal Waters	Done by written annual reports of catch
NH F&G Marine Recreational Fishing Statistical Survey	striped bass, cod bluefish, pollock, mackerel, winter flounder	during fishing season (at peak times)	N/A	All Tidal Waters	Done by phone and dock-side interview
NH F&G 1997 Scallop Survey	scallops	July-December	9 sites	coastal waters	One-time assessment
NH F&G Rainbow Smelt Program	rainbow smelt (adults and eggs)	winter months (eggs in March)	5 sites	Great Bay Estuary	Angler interviews and egg counts; sites on Bellamy, Oyster, Lamprey, Winnicut, & Squamscott Rivers
NH F&G Logbook Programs	catch and effort for species taken by net, seine, trap, etc. (incl. Lobster)	monthly logbooks	N/A	All coastal waters	Logbooks req'd for all holders of netters license, req'd for some lobster license holders
Seabrook Station Shellfish Program	softshell clam spat, adults, disease, predators	clams and disease: 1/yr; predators: 2 times/month	clams: 5 flats, predators: 3 sites	Hampton Harbor	—
Seabrook Station Finfish Program	finfish species	monthly, Apr-Nov	3	Hampton Harbor	Sampling by seine haul, data from 1975 to present

**Table 4: continued**

Program	Parameters	Frequency of Monitoring	Number of Sampling Sites	General Area Sampled	Comments
UNH Estuarine Lobster CPUE Program	lobster catch per unit effort (CPUE)	April-Oct	5	Great Bay Estuary	—
UNH Atlantic Coast Lobster CPUE Program	lobster catch per unit effort (CPUE)		6	Atlantic Coast	Sites range from New Castle, Wallis Sands, and 4 other (summer only) sites
NMFS Commercial Fishing Catch Data	commercial catch (lbs) for 33 fish species, 11 invert. species	variable	comm. fish piers	All tidal waters	—
Coastal 2000 Program	WQ, sediment & tissue toxicity, fish populations, habitat indicators	one sample	up to 50 sites	Great Bay Estuary, Hampton Harbor	One-time sampling (to begin summer of 2000) to establish baseline conditions

**Table 5: Other Natural Resource Monitoring Programs in Coastal New Hampshire.**

Program	Parameters	Frequency of Monitoring	Number of Sampling Sites	General Area Sampled	Comments
NH DES Biomonitoring Program (prelim.)	macroinvertebrate, fish, habitat assess.	Sites sampled once	10 sites	Coastal Watershed	Program began in 1995 and is still evolving.
GBNERR/JEL Estuarine Resource Program	variety of estuarine resources	Annual program	variable; dependent on parameter	Great Bay Estuary	Shellfish, macroalgae, eelgrass, plankton, etc. on annual-rotating basis
GBNERR/ASNH Winter Bird Survey	population of waterfowl, other species	One survey/count per year	numerous	Coastal Watershed	Survey also conducted in other areas of the state
Land Use Mapping Updates (RPCs)	land use	Ongoing	all towns	All Coastal Watersheds	Towns updated each year varies
USGS Stream Gauging	stream flow	Continuous	5 sites	Oyster, Exeter, Lamprey, Cocheco, Salmon Fall Rivers	—
NHCP Restored Salt Marsh Monitoring	soil salinity, vegetation, other bio. indicators	Seasonal pre- and post restoration	8 sites	Coastal NH	Post-restoration monitoring every 2 yrs; more sites in future
NHPA Mitigation Monitoring Program	eelgrass, mudflat, salt marsh	—	—	Piscataqua River	—
Coastal 2000 Program	WQ, sediment & tissue toxicity, fish populations, habitat indicators	One sample	up to 50 sites	Great Bay Estuary, Hampton Harbor	One-time sampling (to begin summer of 2000) to establish baseline conditions
UNH Open Ocean Aquaculture Benthic Program	benthic comm. & sediment texture	Monthly	8 sites	Atlantic Ocean	—
UNH Open Ocean Aquaculture Epibenthic Program	epibenthos (by video)	Monthly (3-4 hr video per month)	2 sites	Atlantic Ocean	—

**Table 6: NHEP Monitoring Activities 2001-2002**

	Responsible Party	2001	2002		
<b>Monitoring Plan Coordination and Implementation</b>					
Maintain Coastal Scientist position	NHEP/DES (DES 25%)	\$78,000	\$78,000		
Data Coordination and Management	Coastal Scientist	✓	✓		
Establish Technical Advisory Committee	NHEP	✓			
Develop Baseline of Environmental Conditions	Coastal Scientist	✓			
Annual Synthesis Report	Coastal Scientist	✓	✓		
Monitoring Plan review, evaluation, update	Coastal Scientist & Tech Adv Com	✓	✓		
<b>Monitoring Activities</b>					
Restructure NH DES freshwater and salt water ambient sampling programs to include additional sampling stations and parameters	DES	\$13,000	\$13,000		
Contribute to operational costs for maintaining the in-situ real time data loggers.	Jackson Lab, GB Research Reserve	\$10,000	\$10,000		
Microbial Source Tracking to routinely monitor surface water samples using DNA identification.	Jackson Lab	\$20,000	\$20,000		
Clam and oyster contaminant exposure testing: Monitor beds on rotational basis.	Jackson Lab	\$5,000	\$5,000		
Predatory fish contaminant exposure: Investigate monitoring in year 2001 and conducting monitoring in 2002.	DES	✓	TBD		
Population assessments for clams and oysters: bed dimensions, density, and population structure. Sample beds on rotational basis every 3 years.	NH F&G	\$4,000	\$4,000		
Map shellfish bed dimensions from using GIS.	UNH Complex Systems	\$4,000	\$4,000		
Oyster disease testing for MSX and Dermo at five beds annually.	NH F&G	\$5,000	\$5,000		
Land Use/Habitat Metadata Analysis	UNHComplex Systems, NHCP	✓	TBD		
<b>Total Annual Cost to NHEP</b>	<b>\$119,500</b>				

✓ Denotes no additional cost to NHEP

**Table 7: Existing and Proposed Monitoring Programs for Bacteria and Disease-causing Organisms**

Monitoring Component	Existing Long-Term Programs	Monitoring Gaps	Recommended Actions	Responsible Party	NHEP Monitoring
<b>1. Fecal Indicator Bacteria</b>					
a. Fecal coliforms	GBNERR/JEL, NHCP Ambient Monitoring Program (four sites in Great Bay Estuary sampled once monthly at high and low tides)	Limited spatial coverage in Great Bay Estuary.	None	GBNERR/JEL	
	NHDES-Shellfish program (Monthly sampling at 60-75 sites at low tide; 9-12 samples/yr)	Does not include enterococci in warm weather (recreational use)		NH DES	
	Great Bay Coast Watch (Monthly sampling at 22 sites April-November)	Only fecal coliforms and not in Hampton/Seabrook Estuary		GBCW	
	NPDES (Occasional and routine analysis at limited number of WWTPs)	No consistent database on WWTP contaminant discharges		WWTP operators	
b. Enterococci/E. coli	GBNERR/JEL, NHCP Ambient Monitoring Program (four sites in Great Bay Estuary sampled once monthly at high and low tides)	Limited spatial coverage in Great Bay Estuary.	weekly sampling in estuarine areas used for swimming; late June-August	Sample collection-DES Analysis-JEL or DES	Restructure DES ambient and shellfish sampling programs for spatial coverage and E. coli in freshwater samples.
	NHDES-Beach Program (Weekly sampling at 9 coastal and 9 freshwater public beaches)	No coordination of sample location and timing with other programs		NHDES	
	NPDES Permit Monitoring (Mostly routine weekly analysis at some WWTPs)	No consistent database on WWTP contaminant discharges		WWTP operators	
	NHDES Ambient Program (3 samples/site at ~ 40-50 sites)	Samples not collected every year; monitoring not designed to assess public health in recreational water		NHDES	
<b>2. Microbial Pathogens</b>					
a. Bacteria	none	Historical monitoring as part of research projects discontinued	Routine monitoring of oysters in GB late May-June, September	JEL	
	none	No monitoring, only research	1-2 samples/week at popular swimming areas	NHDES sampling JEL/NHDES analysis	
b. Viruses	none	No monitoring, only research	Monthly monitoring for enteric viruses at shellfish program sites	NHDES sampling UNH/Micro analysis	
c. Protozoa	none	No monitoring, only research	Monthly monitoring for protozoa pathogens at shellfish program sites	NHDES sampling UNH/Micro analysis	
<b>3. Microbial Source Tracking</b>	NHDES/JEL Pilot Monitoring (~every 2 weeks & during rain events in Varney Bk (Bellamy R.) and Hampton/Seabrook Estuary)	Applied, one-time research and pilot monitoring project; no routine monitoring	a. Routine source identification Monthly monitoring for E. coli at Shellfish Program sites b. Specific source location tracking Iterative identification and elimination of specific sources of concern	NHDES sampling UNH/JEL analysis NHDES sampling UNH/JEL analysis	Use microbial source tracking to monitor samples for routine source identification and specific source location tracking.
<b>4. Harmful Algal Blooms</b>					
a. PSP toxin	NHDES/NHF&G PSP/Red Tide Program (1-2 samples/week, April-October at two sites)	Limited number of sites and only testing in blue mussels	1-2 samples/week at more sites, Apr-Oct, include surf clams off coast	NHDES/NHF&G	
b. HABs	NHOSP/GBCW (Weekly during late spring-early fall at one site)	Limited # of sites, no specific HABs targeted, observation of presence only	monthly/weekly sampling on coast Apr-Oct	GBCW sampling expert observation	

**Table 8: Existing and Proposed Monitoring Programs for Eutrophic Conditions.**

Monitoring Component	Existing Long-Term Programs	Monitoring Gaps	Recommended Actions	Responsible Party	NHEP Monitoring
1. Dissolved and particulate nutrients; Chlorophyll a; suspended particulates; DO	GBNERR/JEL Monitoring Program:	Limited spatial coverage in Great Bay Estuary.	Collect additional samples (5 sites)	Sample collection-DES	Restructure DES ambient and
	Three sites in Great Bay Estuary sampled once monthly at high and low tides; dissolved inorganic N and P, chlorophyll a, TSS, POM; DO, % saturation	No long term sites in Hampton or Little Harbors	in conjunction with NHDES shellfish waters sampling program (once monthly, 10 months)	Sample analysis-JEL	shellfish sampling programs for spatial coverage and additional parameters.
	DES Ambient	Samples not collected every year	Collect additional samples (4 sites HH; 2 sites LH) in conjunction with NHDES shellfish waters sampling program (once monthly, 10 months)	Sample collection-DES Sample analysis-JEL	(same as above)
	40-50 stations in coastal watershed 3 samples/station annually - DO		Sample consistently at strategic freshwater locations as determined by existing database.	NHDES	(same as above)
	DES Shellfish (ancillary): 8 sites in GB and HH, monthly Apr-Oct, DO, TSS, chlor a, nitrate, % organic				
2. Proliferation of nuisance macroalgae	CICEET RECOMS	Two sites supported by GBNERR Funding for sites in Lamprey Oyster and Bellamy ends 12/2000	Establish one or two additional sites with NHEP funds	UNH JEL	Maintenance and operation of existing in-situ instruments.
	Five sites in Great Bay Estuary; automated fluorometry measured every half hour April -December: Chlor a, turbidity, DO, % saturation,	No sites in Salmon Falls, Cocheco Upper Piscataqua, or Little Bay	Provide support operational for three to five sites with NHEP funds	UNH JEL	
	NPDES	No sites in Hampton or Little Harbors			
	Occasional nutrient analysis, TSS, and BOD at some WWTP's;	No consistent database on WWTP nutrient inputs	Routine weekly analysis of WWTP effluent	WWTP operators	
	Great Bay Coast Watch (Twenty sites sampled twice per month at high and low tides) Turbidity, BOD	Choice of sites may not be optimal	Re-examine site locations partial NHEP support for program	Great Bay Coastwatch	
3. Seagrass areal cover	GBNERR/JEL Monitoring program (Selected sites monitored every five years)	Inadequate spatial and temporal coverage	Annual or semi-annual overflights in August, using thermal infrared photography or hyperspectral imaging. Funding provided by NHEP	Imaging-contractor Image analysis- UNH Complex systems	
	No consistent program	Inadequate spatial and temporal coverage	Annual or semi-annual overflights in August, using thermal infrared photography or hyperspectral imaging. Funding provided by NHEP	Imaging-contractor Image analysis- UNH Complex systems	

**Table 9: Existing and Proposed Monitoring Programs for Toxic Contaminants.**

Monitoring Component	Existing Long-Term Programs	Monitoring Gaps	Recommended Actions	Responsible Party	NHEP Monitoring
<b>1. Spatial/temporal trends of toxic contaminants</b>					
a. Sediments	USEPA/NHDES/JEL Coastal 2000 (40 sites/year for 2000 & 2001 sampled once each year)	limited longevity of program (at present, will end after 2001)	Continuation of Coastal 2000 after 2001; annual sampling of subset of sites	UNH sampling contract lab analysis	
	PNSY Sampling Program	Portsmouth Harbor only			
b. Tissue	USEPA/NHDES/JEL Coastal 2000 (40 sites/year for 2000 & 2001 sampled once each year)	limited species and longevity of program (ends after 2001)	expand NH-Gulfwatch; incl. oysters/clams	NHDES/UNH-JEL	Clam and oyster contaminant exposure; sample beds on 3-year rotation
	GOMC/NHDES/JEL Gulfwatch (6-7 sites/y for 2000 & 2001; rotate through 20 sites in 3 years)	limited spatially and by species; blue mussels only	expand C2K; incl. bluefish/striped bass	NHDES/UNH-JEL	Predatory fish contaminant exposure
	NOAA NS&T Mussel Watch Program (2 sites every 2 years)	limited sites and only mussels	extend C2K and Gulfwatch beyond 2001	NHDES/UNH-JEL	
	PNSY Sampling Program	Portsmouth Harbor only; mussels and juvenile lobsters only	Coordinate with other agencies: Audubon	NHDES & Audubon	
c. Water	NPDES Permit Monitoring (some toxic metals occasionally at some WWTFs)	no routine monitoring of effluent discharge quality	Dry/wet weather monitoring at WWTFs	NOAA	
	Mercury Deposition Network (weekly monitoring of mercury at New Castle and Laconia, NH)	iterative identification of sources, especially stormwater		PSNY	
	UNH AIRMAP Monitoring Program	mercury only	Dry/wet weather monitoring at WWTFs	NHDES/permitees	
d. Air	NHDES Air Quality program (VOCs in Portsmouth)	program not supported after 2001	Dry/wet weather monitoring at stormwater outfalls	NHDES/UNH-JEL sampling NHDES/UNH-analyses	
	Coastal 2000 (Acute toxicity tests on sediments from 40 sites/yr)	limited stormwater monitoring		NH DES	
<b>2. Effects of Toxic Contaminants on Biota</b>					
	NPDES Permit Monitoring (whole effluent toxicity tests occasionally at some WWTFs)	no routine monitoring of effluent discharge quality	Extend C2K and Gulfwatch beyond 2001	EPA	
		Ecosystem components not monitored	Dry/wet weather monitoring at stormwater outfalls	NH DES	
			Dry/wet weather monitoring at WWTFs	WWTF operators	
			develop capacity for methods and initiate monitoring using best new approaches	UNH-R&D NHDES	

**Table 10: Existing and Proposed Monitoring Programs for Molluscan Shellfish.**

Monitoring Component	Existing Long-Term Programs	Monitoring Gaps	Recommended Actions	Responsible Party	NHEP Monitoring
1. Shellfish populations					
a. American Oysters	NH Fish and Game (All major beds in Great Bay sampled for abundance and size.)  UNH/JEL population studies (Areal cover, abundance, size and spatfall)	Inconsistent frequency, does not include changes in bed size  Inconsistent frequency, no long-term database	Implement a long-term monitoring program for population structure, abundance, and area covered for all Great Bay Oyster Beds. Conducted annually on a rotational basis to monitor each bed every three years at a minimum.  Update/create geospatial datalayers	Surveys-NH Fish and Game	Oyster population assessment to include bed dimensions, density, and population structure Sample beds rotationally.
b. Softshell clams	Seabrook nuclear power plant monitoring program (NAI) (Major flats in Hampton Harbor sampled annually for abundance and size)  NH Fish and Game monitoring (Variable abundance sampling in Great Bay)  UNH/JEL population studies (Areal cover, abundance, size and spatfall in Great bay and Little Harbor)	Tidal rivers and creeks not sampled  Inconsistent frequency, inadequate for establishing status and trends  Inconsistent frequency, no long-term database, inadequate for establishing status and trends	Initiate annual sampling in the tidal rivers/creeks that includes population structure, abundance and area covered  Update/create geospatial datalayers  Implement a long-term monitoring program for population structure, abundance, and area covered for all Great Bay clam beds. Conducted annually on a rotational basis to monitor each bed every three years at a minimum.  Update/create geospatial datalayers	Datalayers- UNH CSRC  Surveys-NH Fish and Game  Datalayers- UNH CSRC  Surveys-NH Fish and Game	Develop data layers for oysters  Clam population assessments to include bed dimensions, density, and population structure Sample beds rotationally.  (same as above)
c. Blue mussels	None	No consistent database at any location	Update/create geospatial datalayers  None recommended	Datalayers- UNH CSRC  NA	Develop data layers for oysters
d. Sea Scallops	NH Fish and Game scallop studies (Variable abundance and size sampling at Portsmouth Harbor and near coastal locations)  UNH/JEL population studies (Areal cover, abundance, size and spatfall in Portsmouth Harbor)	Inconsistent frequency, inadequate for establishing status and trends  Inconsistent frequency, no long-term database, inadequate for establishing status and trends	Implement annual monitoring program in Portsmouth Harbor and coastal areas: create geospatial datalayers	Surveys- NH Fish and game Datalayers- UNH CSRC	
e. Surf clams	None	No consistent database at any location	Develop a Sea Sampling Program with local fishermen to generate abundance population and locational data Create geospatial datalayers	NH Fish and Game Datalayers- UNH CSRC	
f. Ocean quahogs (mahogany)	None	No consistent database at any location	Develop a Sea Sampling Program with local fishermen to generate abundance population and locational data Create geospatial datalayers	NH Fish and Game Datalayers- UNH CSRC	

**Table 10: Existing and Proposed Monitoring Programs for Molluscan Shellfish (continued).**

Monitoring Component	Existing Long-Term Programs	Monitoring Gaps	Recommended Actions	Responsible Party	NHEP Monitoring
g. European oysters (Belon)	None	No consistent database at any location	None recommended	NA	
h. Razor clams	NH Fish and Game Estuarine Monitoring program (Some data available for 1980-1981)	Inconsistent frequency, inadequate for establishing status and trends	None recommended	NA	
<b>2. Harvest Pressure</b>					
a. Oysters	None 1997 F&G survey 1990 UNH Harvest survey	Inconsistent frequency, inadequate for establishing status and trends	Establish harvest reporting system for recreational harvesters	NH Fish and game	
b. Softshell clams	NH Fish and Game surveys (Variable on days flats are open in Hampton Harbor - # of recreational harvesters assuming harvest = legal limit)	Does not account for illegal take, only includes Hampton Harbor	Establish harvest reporting system for recreational harvesters	NH Fish and game	
c. All other species	None	No consistent database at any location	Establish harvest reporting system for recreational and commercial harvesters of sea scallops, surf clams and ocean quahogs	NH Fish and game	
<b>3. Disease Monitoring</b>					
a. Oyster disease	NH F&G MSX and Dermo Once or twice per year at 3-5 locations	Not all locations sampled every year	Sample a minimum of five locations each year. Contract analyses to Rutgers or Maine	NH Fish and game Contract lab	Sample 5 beds of oysters annually for MSX and Dermo
b. Clam disease	Seabrook station (neoplasia monitoring annually at five clam flats)	No data for Great Bay or Little Harbor	Establish a baseline for Great Bay and Little Harbor	NH F&G	
c. All other species	None	No consistent database at any location	None recommended	NA	
<b>4. Predation pressure</b>					
	Seabrook station (Green crab trapping twice monthly at two sites)	No data for Great Bay or Little Harbor, No data on oyster drills	Initiate green crab and oyster drill surveys	NH Fish and Game	
<b>5. Effects of restoration</b>					
a. Eastern oyster	NH F&G conducted one restoration project in the 1980's and monitored for one year	Insufficient to evaluate long-term benefits	Initiate a program to return cultch to recreational beds	NH Fish and Game	
	UNH CICET restoration project in Salmon Falls River, annual monitoring planned	No long-term funding after 2002	Initiate a bed cultivation program	NH Fish and Game	
b. Softshell clam	NH F&G conducted one year restoration project in Hampton Harbor, no clams survived	Insufficient to evaluate long-term benefits	Encourage/support community restoration efforts and implement monitoring	NH Fish and Game	
c. All other species	None	No consistent database at any location	Include this bed in population surveys	NH Fish and Game	
			None recommended	NA	

**Table 11: Existing and Proposed Monitoring Programs for Land Use, Development, and Habitat Protection.**

Monitoring Component	Existing Program	Monitoring Gaps	Recommended Actions	Responsible Party	NHEP Monitoring
<b>1. Growth indicators</b>					
(Impervious surfaces)	None	Maintenance of related databases and integration and interpretation of all related data  Need means of quantifying impervious surfaces	Establish central repository; establish criteria of database formats; develop framework to integrate and interpret data  Test developing methods in Seacoast	CSRC & NHOSP, GBNERR, NHEP  CSRC & NHOSP	A Needs Assessment will be conducted in 2001 to explore methods and costs for monitoring land use, development, and habitat protection.
(Land use and cover; Developed/undeveloped land)	Land Use Mapping Updates (RPCs) for all coastal communities, ongoing	Ensure consistent annual updates from all towns  Update and establish monitoring based on NHEP Critical Lands Analysis	Acquire land use info from towns Acquire and interpret aerial images  Establish central repository for all related databases; establish criteria for consistent database formats	towns/RPCs & CSRC/NHOSP NOAA/CSRC/NHOSP/NHEP  CSRC & NHOSP, GBNERR, NHEP	NHEP Coastal Scientist coordinate
(Human population)	NHOSP/US Census Bureau	None			
(Building starts: school enrollment construction permits)	Municipal database updates (ongoing for building starts and school enrollment)	Ensure consistent annual updates; and data consistency	Establish central repository; establish criteria of database formats; develop framework to integrate and interpret data	CSRC & NHOSP, GBNERR, NHEP	NHEP Coastal Scientist will coordinate
<b>2. Permanently Protected Habitats</b>					
(Protected lands & Important habitats)	SPNHF/ UNH CSRC (all coastal municipalities, annually)	Need common regional approach and definition for protected lands & important habitats  Establish long-term monitoring program because not always comprehensive  Need integrated database with info on protected lands & habitat  Maintenance of related databases and integration and interpretation of all related data to assess changes in acreage of protected habitats.	Define & establish quantification method  Acquire, interpret & update databases for important habitats  Integrate protected land and important habitat databases  Establish central repository; establish criteria of database formats; develop framework to integrate and interpret data	NHEP & NHOSP  towns/RPCs & CSRC/NHOSP NOAA/CSRC/NHOSP  CSRS, SPNHF, NHEP  CSRC & NHOSP, GBNERR	NHEP Coastal Scientist will coordinate
<b>3. Sprawl</b>	None	Need regional definition and quantification method for sprawl  Establish long-term monitoring program  Separate databases for population & land development in densely and sparsely populated areas  population density  Maintenance of related databases and integration and interpretation of all related data to assess changes in acreage of protected habitats.  Need population densities in developed and less-developed areas	Determine common definition & establish quantification method  Acquire land use info from towns Acquire human population data  Modify existing databases for land development and population to differ between areas varying in	CSRC, NHOSP, NHEP  towns/RPCs & CSRC/NHOSP NHEP/CSRC/NHOSP  NHEP, NHOSP, RPCs, CSRS  CSRC & NHOSP, GBNERR	NHEP Coastal Scientist will coordinate
	NHOSP/US Census Bureau (human population monitoring)			NHOSP	

**Table 12: Existing and Proposed Monitoring Programs for Species and Habitats.**

Monitoring Component	Existing Long-Term Programs	Monitoring Gaps	Recommended Actions	Responsible Party	NHEP Monitoring
1. Trends in wetland degradation and loss					
a. Tidal Wetlands	National Wetlands Inventory (All wetland tidal and fresh mapped one time)  Natural Resources Conservation Service (USDA) (All tidal wetlands with tidal flow restrictions)  NH Coastal Program Restoration (Inventory of tidal wetlands that are ditched or filled)  NH DES (Inventory wetland alteration permits subtracts impacted areas from total, adds restored areas to total.)  NH Port Authority (Monitors NHPA mitigation sites annual)	No plans to conduct additional surveys  No plans to update by NRCS; however, inventory of restriction removal maintained by NH Coastal Program  Program in Development  Baseline acreage may not be accurate No follow-up on permits  Limited to NHPA sites	Take advantage of any aerial image capture, See Monitoring Goal # III  Encourage NH CP to continue with restoration inventory  Encourage NH CP to continue with restoration monitoring  See 1.a. above Follow up on permits to verify actual acreage disturbed and restored  Integrate into DES database	NH DES  NHCP  NHCP  NH DES  NH DES	A Needs Assessment will be conducted in 2001 to explore methods and costs for monitoring habitats and critical species.
b. Eelgrass	See Monitoring Goal #III				
c. Macroalgae	See Monitoring Goal #III				
d. Freshwater wetlands	NH DES (Inventory wetland alteration permits subtracts impacted areas from total, adds restored areas to total.)  Municipal Prime wetlands mapping (Location and frequency varies)  NH F&G anadromous fish monitoring (All fish ladders monitored during annual spawning run - Oyster, Cocheco, Exeter, Lamprey, Taylor, and Winnicut Rivers)  NH F&G estuarine fish survey (10 sites in Great Bay, 4 sites in Hampton, sampled monthly Jun-Nov)  Coastal 2000 (40 sites in Great Bay)  NH F&G Shad restoration (Daily monitoring of spawning run Apr-June at Exeter River)  NH F&G Atlantic salmon restoration (Annually, spring and fall, at Cocheco and Lamprey Rivers)  NH F&G voluntary creel surveys (Catch of sea run brown trout and striped bass in all tidal waters.)	Baseline acreage may not be accurate No follow-up on permits, does not include stormwater treatment systems that may function as wetlands  May not be included in NH DES/Granite database Data not widely distributed  Seine hauls only-does not sample fish from deep water  No consistent long-term funding  Other tidal rivers not monitored  NA  Data not widely distributed or integrated	More accurate delineation of small wetlands Follow up on permits to verify actual acreage disturbed and restored  Identify SW treatment systems that become functional wetlands (swales, ponds, etc.)  Integrate information into DES database  Better data management, integration and distribution  Initiate trawl surveys or continue at selected Coastal 2000 sites  See above  No action recommended until success of shad restoration program verified  No action recommended until success of salmon restoration program verified  Better data management, integration and distribution	Towns and RPC's NHDES  NHDES  RPC's and DES  NH F&G  NH F&G  NH F&G  NH F&G	
2. Trends in resident finfish populations					

**Table 12: Existing and Proposed Monitoring Programs for Species and Habitats (continued).**

Monitoring Component	Existing Long-Term Programs	Monitoring Gaps	Recommended Actions	Responsible Party	NHEP Monitoring
2. Trends in resident finfish populations (continued)	NH F&G recreational fishing surveys (Catch of striped bass, cod, bluefish, pollack, mackerel, winter flounder) NH FF&G rainbow smelt program (Annual angler interview and egg counts on spawning grounds in Bellamy, Oyster, Lamprey, Winnicut, and Squamscot Rivers.) NH F&G logbook program (Catch effort for all species taken by seine and trap, reported monthly)	Data not widely distributed or integrated  Data not widely distributed or integrated  Data not widely distributed	Better data management, integration and distribution  Better data management, integration and distribution  Better data management, integration and distribution	NH F&G  NH F&G  NH F&G	NHEP Monitoring
3. Trends in groundwater quality	Seabrook Station finfish monitoring (Monthly trawls at 3 coastal stations, monthly seine hauls 3 estuarine stations for all species) Some project /site related monitoring supplies	None  No comprehensive program for contaminated wells, drinking water	Better integration of data  Examine available groundwater data to Need to integrate existing data	NHEP  NHDES determine monitoring needs	
4. Trends in Meeting designated uses	NH DES 305b report (All surface water bodies reported every two years)	Unknown	Continue 305b reporting, improve data dissemination and integration	NHDES	
5. Trends in water suitability for aquatic life					
a. Benthic macroinvertebrates	NH-PA mitigation monitoring (5 tidal mitigation sites monitored annually) UNH Open Ocean Aquaculture Benthic monitoring (Benthic infauna at 8 sites one mile south of Isles of Shoals, monthly) UNH Open Ocean Aquaculture epibenthic monitoring (Video surveys of bottom fauna) NAI/Seabrook Station macrobenthos monitoring program (6 coastal sites for all flora and fauna, 3 times per year) NAI/Seabrook Station epibenthic crustacean monitoring program (Lobster larvae @ 3 sites, 15 lobster at 2 sites, crab larvae @ 2 sites, crabs @ 2 sites with lobster)	Limited geographic coverage  Limited geographic coverage  Limited geographic coverage  Limited geographic coverage	Coordinated data analysis for all benthic monitoring programs, synthesize and disseminate data  See above  See above  See above  Integrate with Fish and Game data: synthesize and disseminate data	NH F&G and NHEP  UNH  UNH  NAI/Seabrook Station  NH F&G and NHEP	
	NH F&G juvenile lobster monitoring (SCUBA surveys of juveniles at 2 Great Bay and 1 coastal site, monthly Apr-Dec)	Data not widely distributed	Integrate with NAI data: synthesize and disseminate data	NH F&G and NHEP	
	NH DES stream biomonitoring (10 freshwater stream sites sampled one time for macroinvertebrates and fish)	Inadequate frequency	Establish biennial schedule	NH DES	

**Table 12: Existing and Proposed Monitoring Programs for Species and Habitats (continued).**

Monitoring Component	Existing Long-Term Programs	Monitoring Gaps	Recommended Actions	Responsible Party	NHEP Monitoring
c. Wildlife	Coastal 2000 (Benthic infauna at 40 sites, sampled once annually 2000 and 2001)	No continuation planned	Continue at selected sites if appropriate Sample every 3-4 years	NHEP/Contract	
	GBNERR horseshoe crab monitoring program (Observational data by volunteers, annually during spawning)	Status for continuation unknown	Encourage Continuation	GBNERR	
	NH F&G/Audubon tern monitoring (Nesting pairs and hatchlings at White Island)	Limited geographic coverage	Encourage Continuation, include Great Bay if appropriate, synthesize and disseminate data	NH F&G and Audubon	
	Audubon winter eagle surveys (Frequent observational data, Nov-Apr)	None	No new action recommended		
	NH F&G/Audubon shorebird surveys (Observational data, spring to fall for all estuarine waters)	Data not widely distributed or integrated	Better dissemination of synthesized data	NH F&G and NHEP	
	NH F&G/Audubon waterfowl surveys (Observational data throughout coast)	Data not widely distributed or integrated	Better dissemination of synthesized data	NH F&G and NHEP	
	F&G hunting and trapping permits (mammals) (Variable with season)	Data not widely distributed or integrated	Better dissemination of synthesized data	NH F&G and NHEP	
d. Reptiles and amphibians		No current comprehensive monitoring	Initiate reptile and amphibian monitoring	EPA and NH F&G	
e. Phytoplankton	See Monitoring goal #III				
f. Large bivalves	See Monitoring goal #IV				
g. Eelgrass	See Monitoring goal #III				
h. Macroalgae	See Monitoring goal #III				
	NAI/Seabrook Station macrobenthos monitoring program (6 coastal sites for all flora and fauna, 3 times/year)	Limited geographic coverage	See Monitoring goal #III for intertidal macroalgae		
h. Stream flow	USGS Stream Gauging (Continuous at 5 sites - Oyster Exeter, Lamprey, Cocheco and Salmon Falls Rivers)	None	Integrate USGS data into other databases (e.g. freshwater fish, anadromous fish, pollutant loading, etc.)	NHEP	
6. Wetland Restoration					
a. Tidal wetlands	See 1.a above				
b. Freshwater wetlands	See 1.d above				
7. Invasive wetlands species		No current comprehensive monitoring	See monitoring goal#III re: remote sensing and vegetation mapping	UNH CSRC & NHEP	

## QUESTIONS TO BE ADDRESSED BY A COMPREHENSIVE MONITORING PLAN

### Questions for Water Quality/ Bacteria and Other Disease Causing Organisms

- Do NH tidal waters meet fecal coliform standards of the National Shellfish Sanitation Program for 'approved' shellfish areas?
- Do NH surface freshwaters meet the state *Escherichia coli* standard of < 126/100 ml?
- Do NH designated freshwater beaches meet the state *Escherichia coli* standard of < 47/100 ml?
- Do NH tidal waters, including swimming beaches, meet the State enterococci standards of < 35/100 ml?
- Do NH tidal waters contain disease-causing and biotoxic organisms (pathogenic bacteria, viruses, harmful algal blooms)?
- Have fecal coliform, enterococci, and *Escherichia coli* levels changed significantly over time?
- Has dry weather bacterial contamination changed significantly over time?
- Has wet weather bacterial contamination changed significantly over time?

### Questions for Water Quality/Impacts of Toxic Contaminants

- Do NH tidal waters and sediments contain heavy metals, PCBs, PAHs, chlorinated pesticides, dioxins/furans, and other toxic contaminants that are harmful to humans, animals, plant, and other aquatic life?
- Are shellfish, lobsters, finfish, and other seafood species from NH coastal waters fit for human consumption?
- Is there evidence of toxic effects of contaminants in estuarine biota?
- Have the concentrations of toxic contaminants in sediment and estuarine biota significantly changed over time?

### Questions for Water Quality/Effects of Nutrients and Turbidity

- Have levels of dissolved and particulate nitrogen and phosphorus significantly changed over time?
- Have levels of phytoplankton (chlorophyll a) in NH tidal waters significantly changed over time?
- Do any surface freshwaters exhibit chlorophyll a levels that do not support swimming standards (20-30 mg/l: partially support; >30 mg/l: does not support)?
- Do any surface tidal or freshwaters show less than 75% saturation of dissolved oxygen? For what period of time?
- Do any surface tidal or freshwaters show a significant change in Biological Oxygen Demand?

- Is there evidence of proliferation of nuisance species associated with elevated nutrient loading?
- Have surface tidal or freshwaters shown a significant change in turbidity (total suspended solids or nephelometric turbidity units) over time?

### **Questions for Sustainability of Shellfish Resources**

- Are 75% of all shellfish (oyster; soft-shell clam) beds open for harvesting?
- Has the number of harvestable clams and oysters in NH estuaries tripled from 1999 levels?
- Are NH shellfish healthy, growing, and reproducing at sustainable levels?
- Are NH shellfish being harvested at sustainable levels?
- Has the incidence of shellfish diseases significantly changed over time?
- Have restoration efforts resulted in a significant increase in the acreage and/or density of soft-shell clam and oyster beds?

### **Questions for Land Use, Development, and Habitat Protection**

- Has the rate of creation of new impervious surfaces in coastal NH watersheds significantly changed over time?
- Has there been a significant change over time in the number of coastal NH watersheds (first or second order) that exceed 10% impervious cover?
- Has the rate of urban sprawl in coastal NH watersheds significantly changed over time?
- Has the acreage of permanently protected important habitats (tidal shorelands, wetlands, rare and exemplary natural communities, large contiguous forest tracts, wetlands with high habitat value, freshwater shorelands) significantly changed over time?
- Has the acreage of privately owned lands managed to benefit wildlife and natural communities significantly changed over time?

### **Questions for Restoration of Critical Species and Habitats**

- Has there been any significant net loss or degradation of tidal or freshwater wetlands in NH?
- Has the abundance, biology, and species composition of resident finfish changed significantly over time?
- Has the quality of groundwater entering NH estuaries significantly changed over time?
- Have the miles of rivers and streams meeting high quality biomonitoring standards significantly changed over time?
- Has the acreage of waters supporting designated uses (fishing, swimming, shellfishing, etc.) significantly changed over time?

- Do the following indicators show that water quality is suitable for aquatic life: aquatic insects/invertebrates, wildlife, fish, diatoms/algae, large bivalves, eelgrass, marshes?
- Have restoration efforts resulted in a significant increase in the acreage of tidal or freshwater wetlands?
- Has the acreage of invasive species (*Phragmites*, purple loosestrife) in NH salt marshes and wetlands significantly changed over time?
- Have restoration efforts resulted in a significant increase in the acreage/density of shellfish beds (soft-shell clams and oysters)?

